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PHYSICIAN UTILIZATION OF A HOSPITAL INFORMATION SYSTEM: A COMPUTER SIMULATION MODEL

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ABSTRACT

The purpose of this research was to develop a computer simulation model that represents the process through which physicians enter orders into a hospital information system (HIS). Computer simulation experiments were performed to estimate the effects of two methods of order entry on outcome variables. The results of the computer simulation experiments were used to perform a cost-benefit analysis to compare the two different means of entering medical orders into the HIS. The results indicate that the use of personal order sets to enter orders into the HIS will result in a significant reduction in manpower, salaries and fringe benefits, and errors in order entry.

INTRODUCTION

There is limited evidence that direct order entry by physicians into a computer-based clinical information system improves medical care or reduces costs (1-3). At the same time, several studies indicate that these systems can alter physician behavior if they are integrated properly into clinical settings (4-5). The major objective of this research was to develop a computer simulation model that represents the process through which physicians enter orders into a hospital (HIS) in providing patient care. The model was used to estimate the effects of two methods of order entry into a HIS. Computer simulation experiments were performed to estimate resource utilization (e.g., physician time, unit secretary time), total time to implement orders, and error rates in order entry.

METHODS

Clinical Setting.

The study was performed in a 1160 bed, private community hospital. Nursing units contain 3-7 computer terminals linked to the hospital information system (HIS). Physicians, nurses, and other authorized hospital personnel can enter and retrieve medical orders and patient data using a keyboard or a light pen. Orders can be entered into the computer system directly by physicians or nurses and unit secretaries may enter orders for the physician. When entering orders, the physician or his/her agent can select screens that display either general orders or personal order sets that are similar to preprinted order sheets (see Figure 1).

Data Collection.

In order to study physician use of the HIS, data were collected from two sources. First, four weeks of patient data were extracted from the HIS purge tapes. These tapes contain data on all the procedures that have been ordered for patients who were discharged from the hospital during this period. They also contain information on who entered each order and the mode of order entry. The second source of data was actual observations of physicians, nurses, and unit secretaries while they were entering, printing, filing, and verifying medical orders.

The Computer Simulation Model.

A computer simulation model was constructed to model order entry into a hospital information system. INSIGHT, a general purpose discrete event simulation language, was used to model the system (6). The model is graphically represented in Figure 2. The symbols represent nodes that are connected to form a network that represents the system being studied.

At Stage A sets of medical orders are created and their arrival in the network is scheduled according to a probability distribution. At Stage B attributes are assigned to each order set. First, the entry method is assigned. Orders may be entered by means of computerized personal order sets that have been developed and stored in the HIS or using the general order screens that come with the HIS. Second the order type is assigned, namely, orders entered directly by physicians or their assistants, written, verbal or telephone orders.

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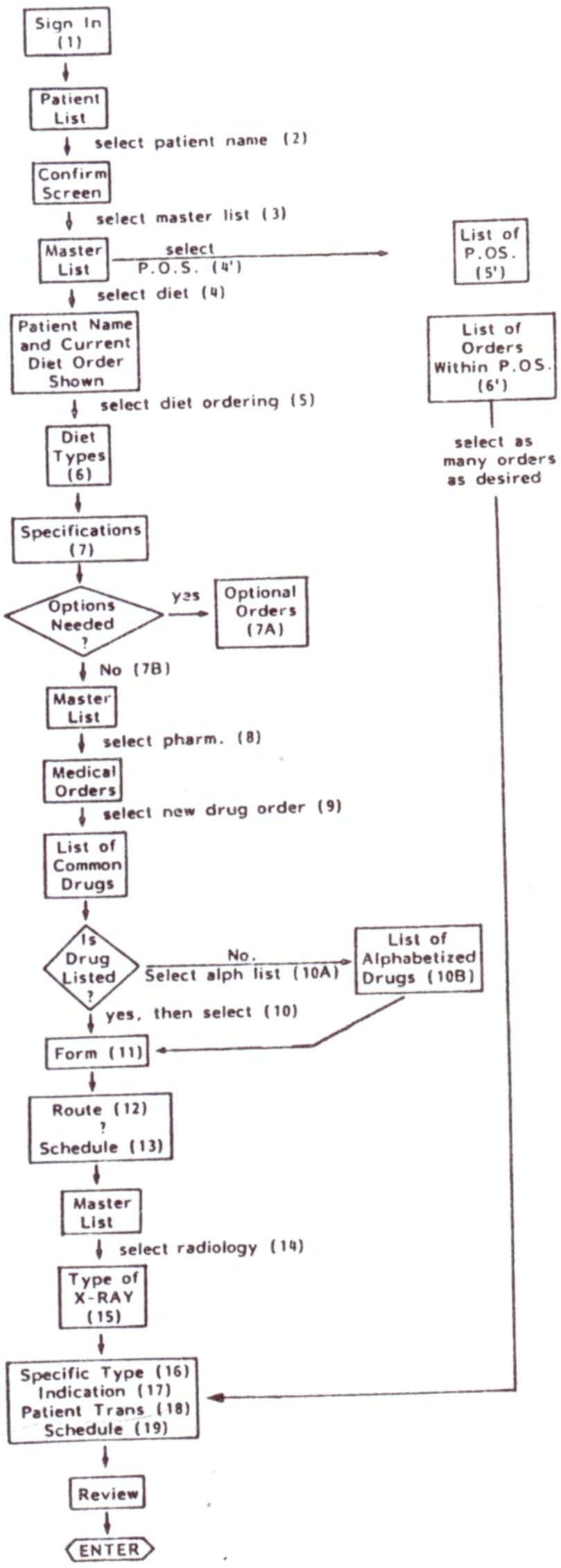
Figure 1
Order Entry - Use of Regular HIS Pathways vs. Use of Personal Order Sets



At Stage C orders are written by the physician, a physician's assistant, or by a unit secretary in the case of verbal and telephone orders. Resources (in this instance personnel) must be available to write orders. If they are unavailable, there may be a delay and the orders remain in a queue. Since personnel perform other functions, decision trees such as the one shown in Figure 3 are used to determine the availability of the resource. There also may be interruptions while personnel are writing or entering orders. Such random interruptions are programmed into the model.

At Stage D orders are entered into the HIS. The time to enter orders is a function of the time it takes to log on to the system to enter an order sets and to correct any errors that are detected during entry. The last two times are determined by sampling probability distributions.

Once entered into the HIS, orders are printed on the unit as well as in the appropriate ancillary services at Stage E. A unit secretary files one copy of the order in the patient's chart at Stage F. A second copy is given to the RN in charge of the patient. Orders are verified by an RN at Stage G. Written and printed orders are compared. If an error is detected, the order is sent back to be corrected and reentered. Otherwise the patient's chart is returned to the chart rack at Stage H.

Computer Simulation Experiments.

The model was used to conduct simulation experiments. These experiments assumed the following resources were available on the nursing unit for order entry: 6 MDs, 3 physicians' assistants, 2 unit secretaries, 2 RNs, 7 terminals and monitors, and 2 printers. A period of 16 hours and a total of 227 order sets were simulated for each experiment.

The initial run replicated the existing conditions on a nursing unit. Written orders account for 89% of the medical orders. One percent are verbal or telephone orders; all but 3% of these orders are entered into the HIS by unit secretaries. Physicians directly enter only 8% of the orders.

In the initial run, unit secretaries, physicians, and physicians' assistants used personal order sets to enter 29%, 50%, and 13% of medical orders, respectively. For the experimental run, the use of POSs was increased to 50%, 75%, and 50%, respectively.

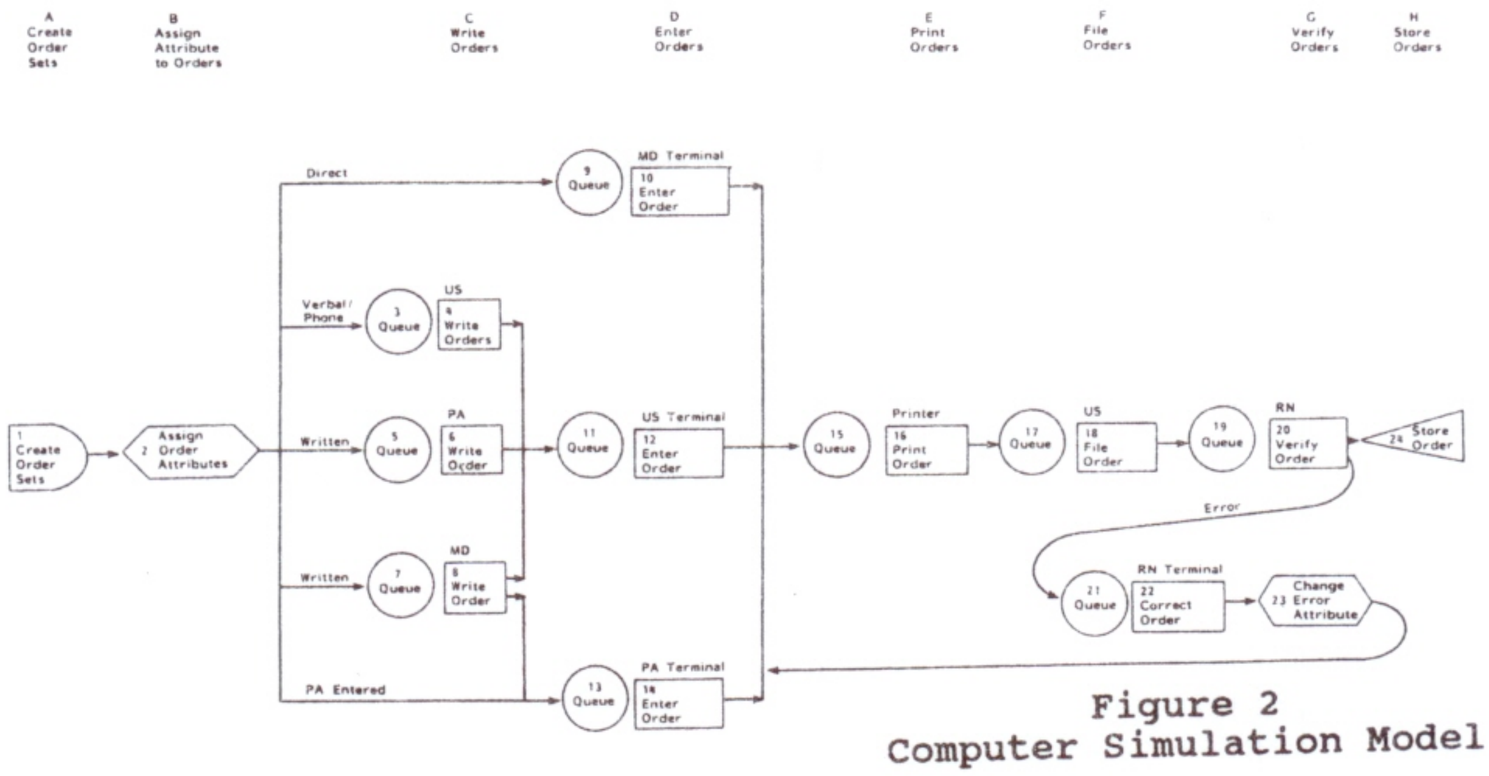


Figure 2
Computer Simulation Model

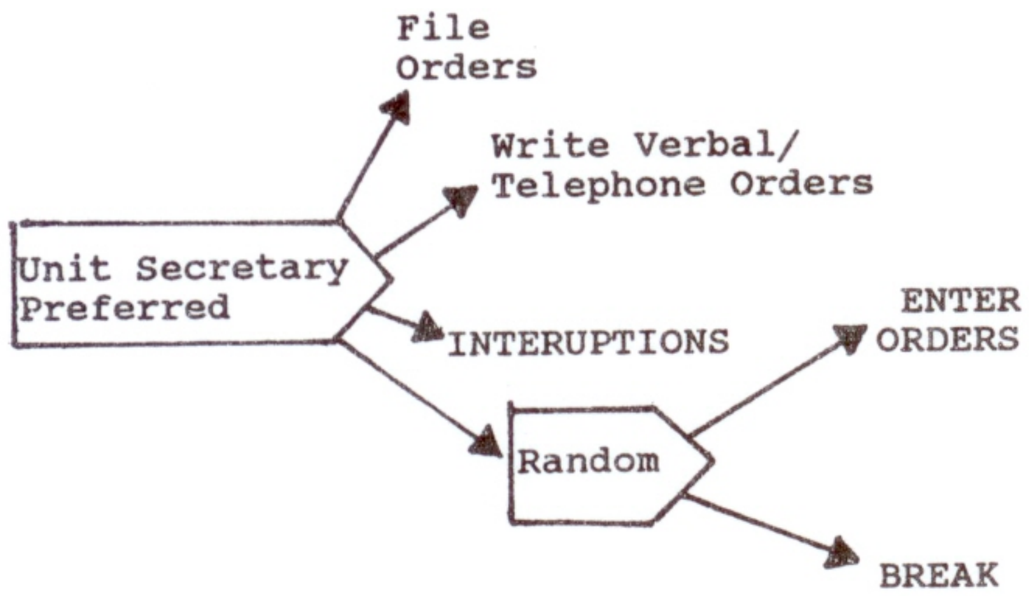


Figure 3
Decision Tree for Unit Secretaries

RESULTS

Table 1 shows the results of the computer simulation experiments

Initial Conditions.

It takes 36.9 minutes on the average to enter, print, file, verify, and store medical orders. Of this time 33.6 minutes are due to the unavailability of personnel, a terminal or a printer. Unit secretaries devote 21.9 percent of their time implementing medical orders through the HIS. The error rate in entering orders is 40.9 per 1000 orders. Eleven percent of these errors are not detected during the order entry process.

Experimental Conditions.

The computer simulation experiment assumed that physicians, physicians' assistants, and unit secretaries increased their use of POSs to enter orders into the HIS. Average time required to implement a set of orders decreased to 33.2 minutes. While the average time to enter orders was reduced by almost 40 percent, the waiting time decreased by less than 10 percent. The unavailability of RNs to verify orders is a major reason for the delay in implementation of orders. Increased use of POSs resulted in a 20 percent reduction in the time that hospital personnel are involved in order entry and a 30 percent reduction in terminal usage. Also, errors in order entry decreased significantly. Overall, there was a 40 percent reduction in undetected errors.

Cost-Benefit Analysis.

The results of the computer simulation experiments have been used to perform a cost-benefit analysis to compare the two means of entering medical orders into the HIS. Over three million medical orders are entered into the HIS annually requiring 53 FTE unit secretaries. The annual cost in salaries and fringe benefits is almost 1 million. The model predicts that the increased use of POSs to process the same volume of medical orders would result in annual savings of 10 FTE unit secretaries, and $180,000 in salaries and fringe benefits.

Also, the analysis indicates that the increased use of predesigned order sets would significantly reduce the number of errors made while entering orders by 40 per cent. It is estimated that errors in order entry could be reduced from 13,624 per year to 5,477.

DISCUSSION

This study has demonstrated how a computer simulation model can be developed and used to analyze the process through which medical orders are entered into a HIS. The model predicts that the increased use of personal order sets to enter orders into HIS can result in a significant reduction in manpower, salaries and fringe

Table 1. Results of the Computer Simulation Experiments

Outcome Variables	Initial Conditions	Experimental Conditions
Average Time to Implement Order set	36.9 mins.	33.2 mins.
Average Order Entry Time:		
MD	4.6 mins.	2.9 mins.
PA	2.6 mins.	1.6 mins.
US	1.8 mins.	1.4 mins.
Waiting Time:		
Order Entry	12.4 mins.	9.9 mins.
Filing Orders	3.9 mins.	3.3 mins.
Verification	17.3 mins.	17.3 mins.
Total	33.6 mins.	30.5 mins.
% Time Involved with HIS		
MD	4.1%	3.5%
PA	0.5%	0.4%
US	21.9%	17.7%
RN	3.0%	3.0%
Terminal	9.8%	6.9%
Error Rates (per 1000 Orders)		
Undetected	4.5	2.7
Detected	36.4	30.3
Total	40.9	33.0

benefits, and errors in order entry. The model represents the standard order entry process that is used in most hospitals that have implemented a comprehensive HIS. Thus, the results should be generalizable to other hospitals that have implemented hospital information systems that facilitate order entry.

REFERENCES

1. Blum, B.I. Clinical Information Systems, Springer-Verlag, New York, 1986.
2. Computerized Hospital Medical Information Systems Need Further Evaluation to Ensure Benefits from Huge Investments. Washington, DC: U.S. GAO, AFMD-81-3, 1980.
3. ADP Systems: Examination of Non-Federal Hospital Information Systems. Washington, DC: U.S. GAO, IMTEC-87-21, 1987.
4. McDonald, C.J., Wilson, G.A., McCabe, G.P. Physician response to computer reminders. JAMA 1980; 244;1579-1580.
5. Barnett, G.O., et al., Quality assurance through automated monitoring and concurrent feedback using a computer-based medical information system. Medical Care 1978: 16:962-968.
6. Roberts, S.D. Simulation Modeling and Analysis with INSIGHT. Indianapolis, IN: Regenstrief Institute for Health Care, 1983.